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EVALUATION OF THE SURFACE CUTOFF MODEL IN THE USA CODE

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15 September 1980

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents a brief study performed to evaluate the incident-wave surface-cutoff model that is used in the Underwater Shock Analysis (USA) Code. Comparisons have been made between USA predictions of pressure and fluid-particle velocity and experimental results obtained with fluid-particle velocity meters and pressure transducers. For the time span encompassing shock-wave excitation, the correlations are good.

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SUMMARY

This report documents a brief study performed to evaluate the incident-wave surface-cutoff model that is used in the Underwater Shock Analysis (USA) Code. Comparisons have been made between USA predictions of pressure and fluid-particle velocity and experimental results obtained with fluid-particle velocity meters and pressure transducers. For the time span encompassing shock-wave excitation, the correlations are good.

PREFACE

The authors express their appreciation to John Gordon of UERD for generously providing the experimental data for this study. The study was performed for the Strategic Structures Division of DNA, with Dr. Eugene Sevin as Chief.

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DISCUSSION

The fluid-structure interaction equations solved by the Underwater Shock Analysis (USA) Code [1] rely not only upon the incident-wave pressure history but the associated fluid-particle velocity as well. Hence, it is important that the change in direction of the fluid-particle-velocity vector that occurs for a near-surface shock wave is adequately treated in the code. To that end, an analytical model of the bulk cavitation has been constructed for USA that fully accounts for such direction changes [1]. The modest study described here compares the USA model predictions with test results that have been provided by the Underwater Explosions Research Division of DTNSRDC [2].

A test-configuration diagram for Shot 8459 under the UERD Project "Sub Shock Motions" is shown in Figure 1. The USA computations required an inferred infinite-fluid pressure history at Point 1 obtained from the measured pressure history; this is shown in Figure 2. With the infinite-fluid pressure history, the USA Code was used to calculate actual pressure and fluid-particle-velocity histories at Points 1, 2, and 3. These are compared with the corresponding measured histories in Figures 3-11.

Figure 3 shows excellent correlation between calculated and measured pressure histories at Point 1. The correlation between the corresponding horizontal fluid-particle-velocity histories in Figure 4 is almost as good, with the only discrepancies being caused by the delay in response of the fluid-particle-velocity meters due to their finite length. Much poorer correlation is observed in Figure 5, which pertains to vertical fluid-particle velocities. This is caused by the fact that the USA Code ignores the effects of gravity, which are small during the time spans of interest.

Figures 6-11, which pertain to Points 2 and 3, exhibit the same characteristics observed in Figures 3-5, with the exception that the direct-wave component of the vertical-velocity response at Point 3 is predicted quite accurately by the USA Code. Finally, note that the late time effects shown in the figures (i.e., those for $t > 105$ msec in Figures 3-5, those for $t > 120$ msec in Figures 6-8, and those for $t > 100$ msec in Figures 9-11) are not treated by the incident-wave cutoff model.

Based upon the agreement between the USA Code predictions and the UERD test results, we conclude that the incident-wave surface-cutoff model developed for the USA Code fully and accurately simulates the pressure and fluid-particle-velocity fields associated with shock waves generated by near-surface underwater explosions.

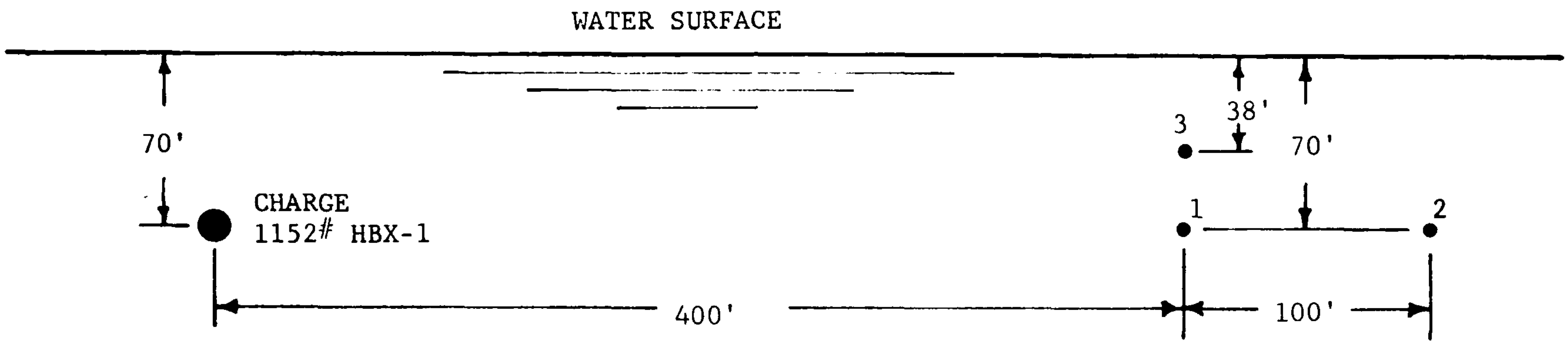

Figure 1. Test Configuration for UERD Shot 8459

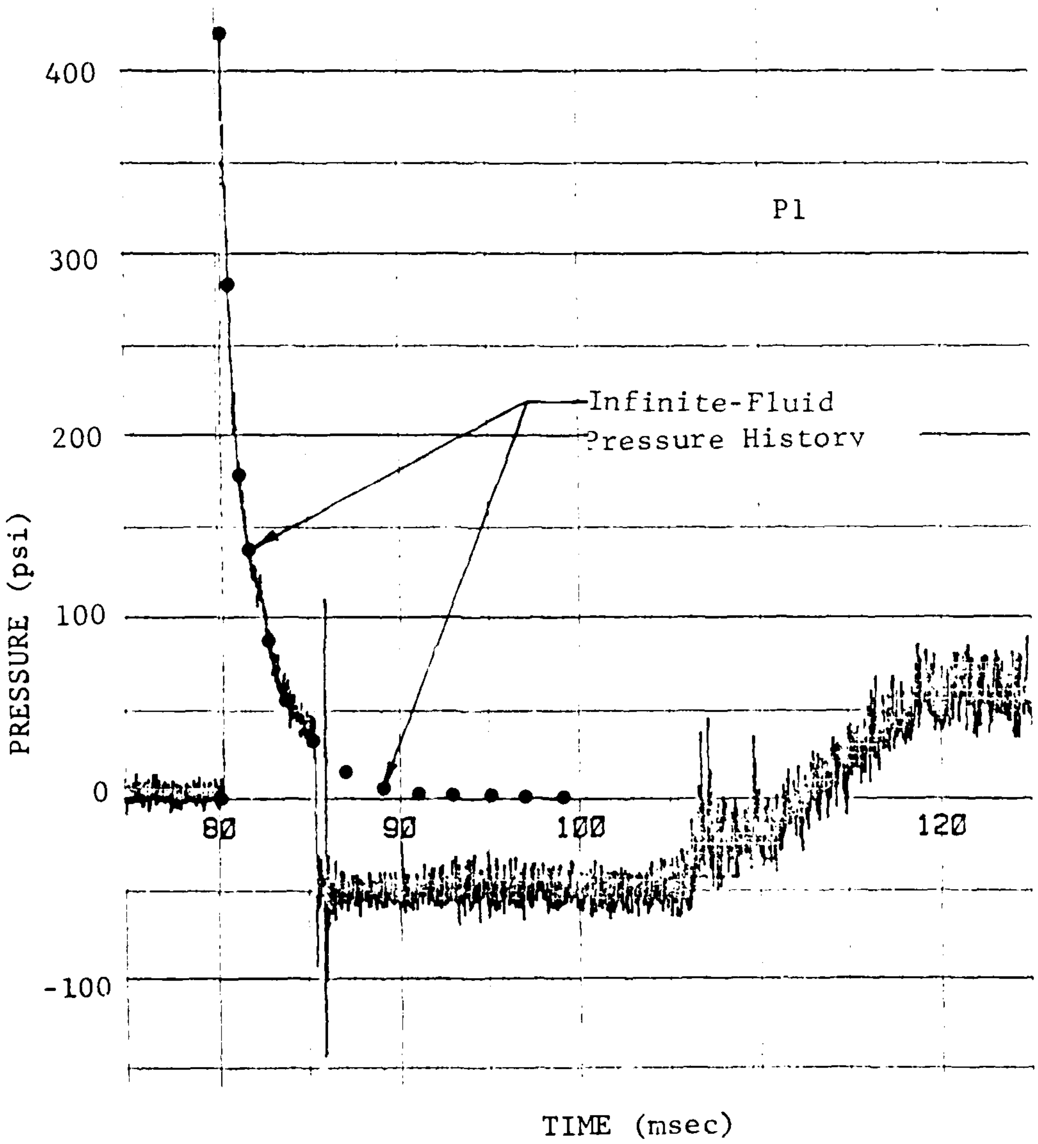

Figure 2. Inferred Infinite-Fluid Pressure History from Experimental Data at Point 1

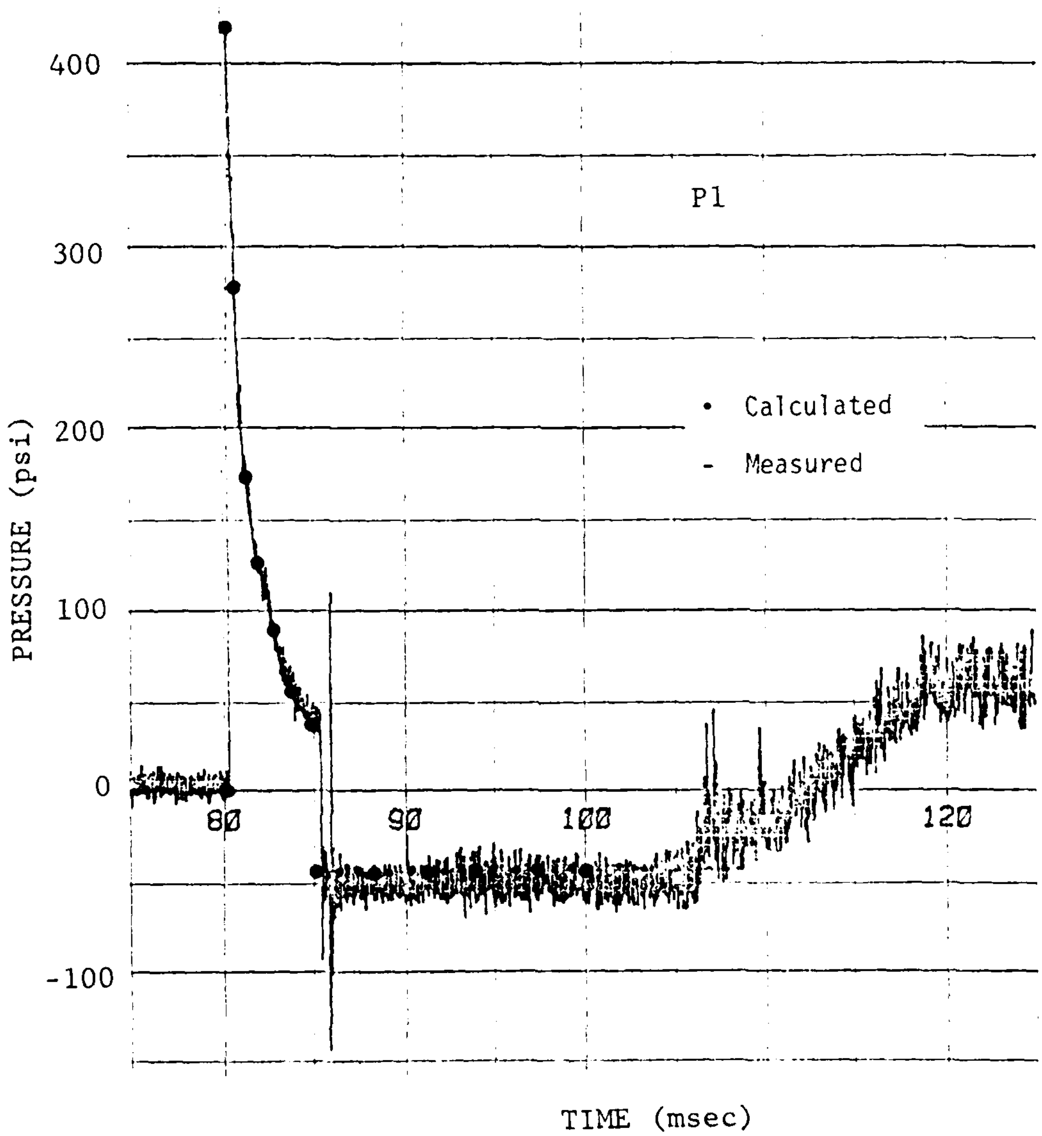

Figure 3. Calculated and Measured Pressure Histories at Point 1

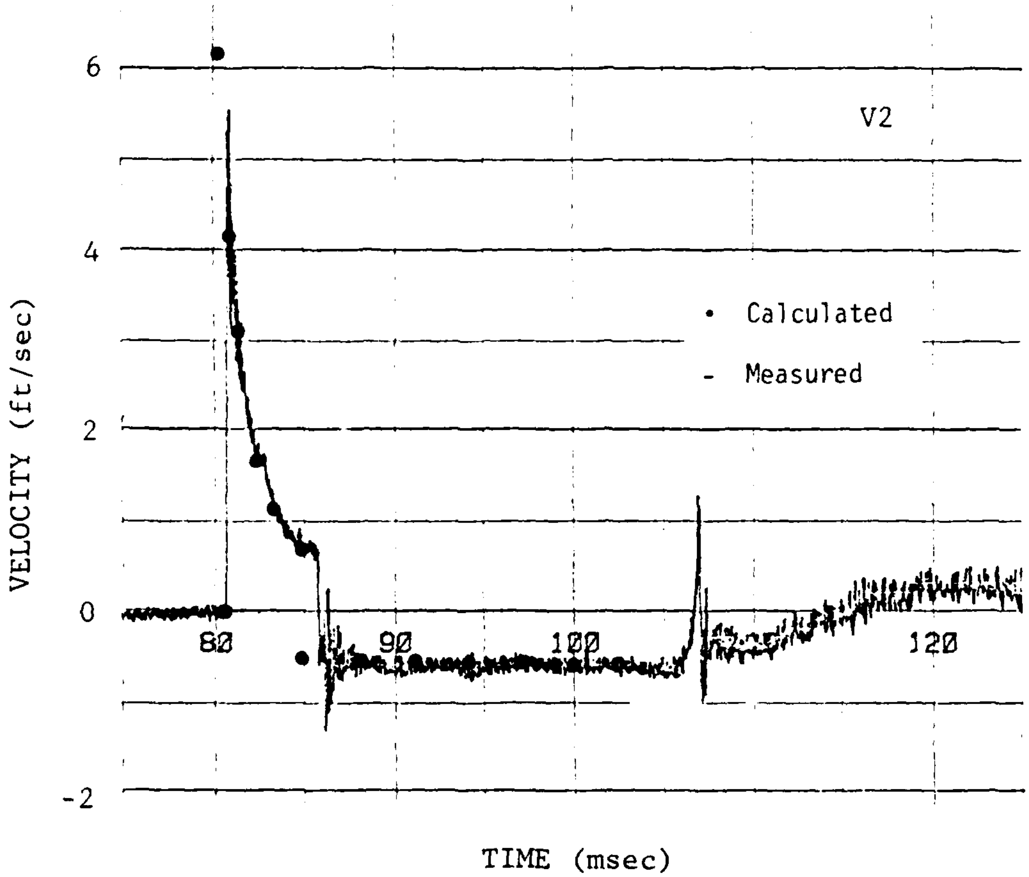

Figure 4. Calculated and Measured Horizontal Fluid-Particle-Velocity Histories at Point 1

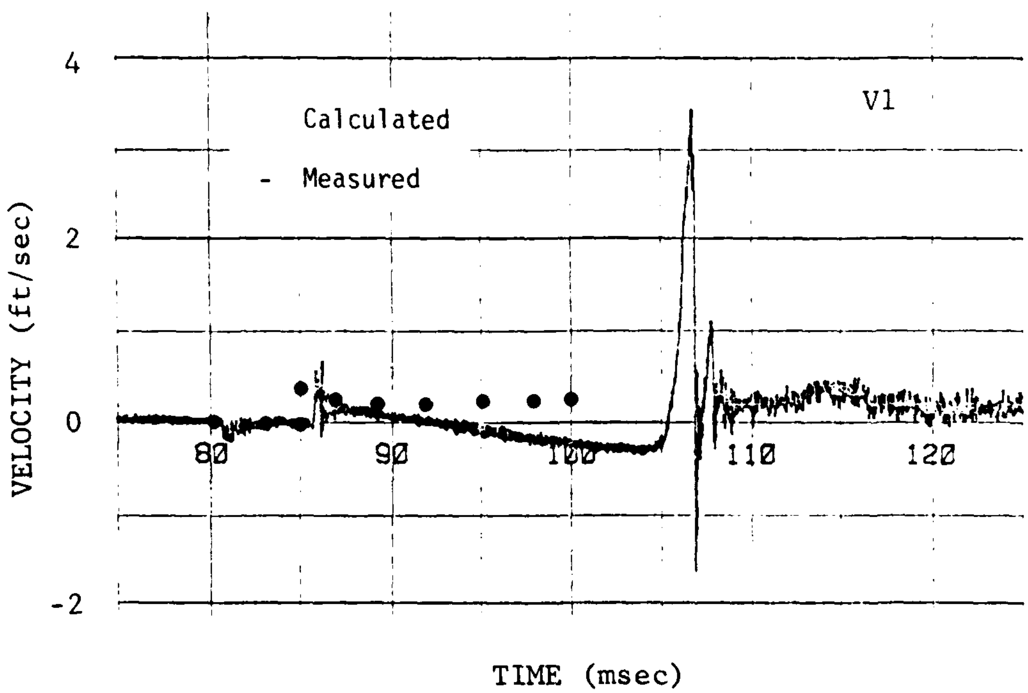

Figure 5. Calculated and Measured Vertical Fluid-Particle-Velocity Histories at Point 1

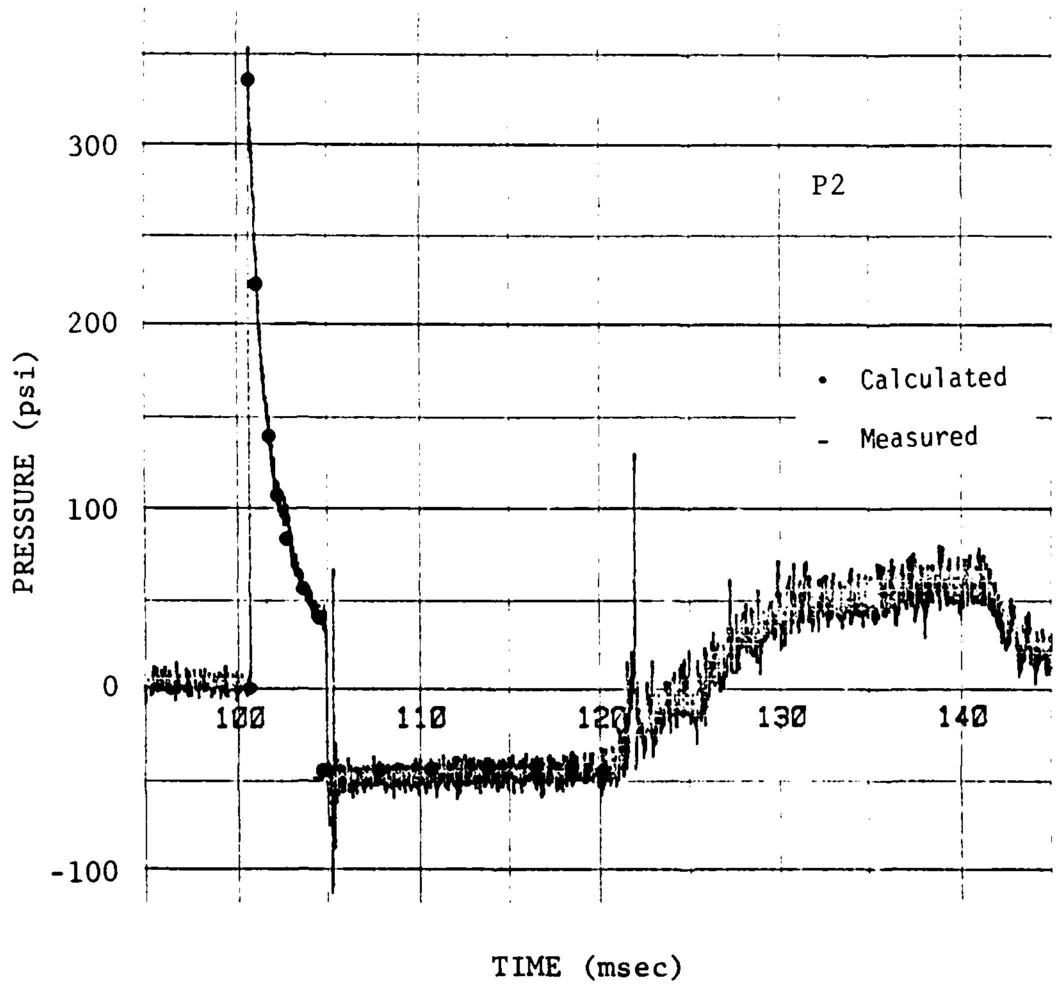

Figure 6. Calculated and Measured Pressure Histories at Point 2

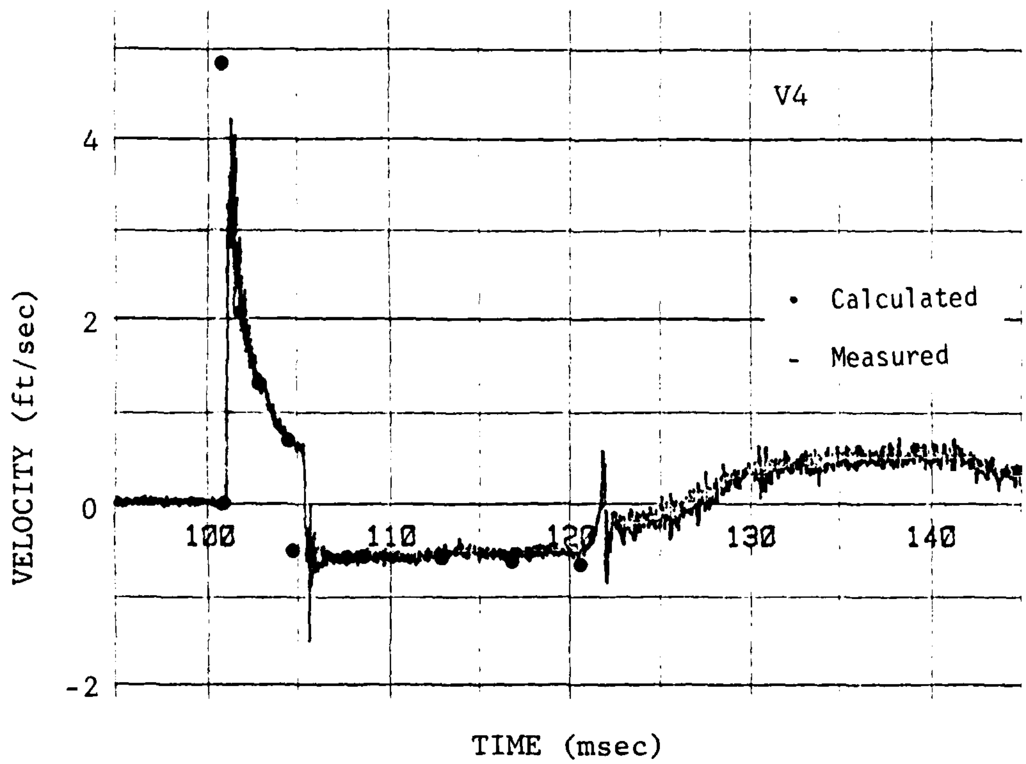

Figure 7. Calculated and Measured Horizontal Fluid-Particle-Velocity Histories at Point 2

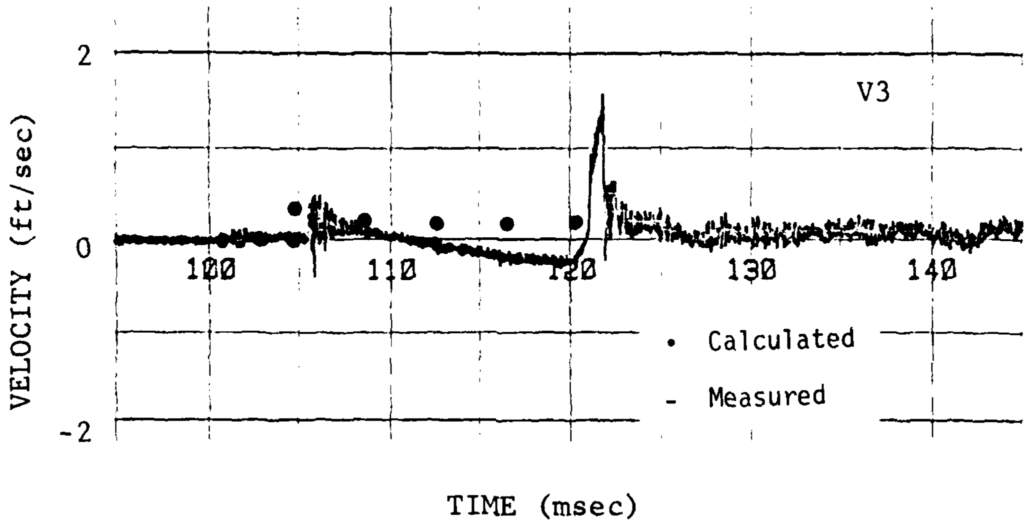

Figure 8. Calculated and Measured Vertical Fluid-Particle-Velocity Histories at Point 2

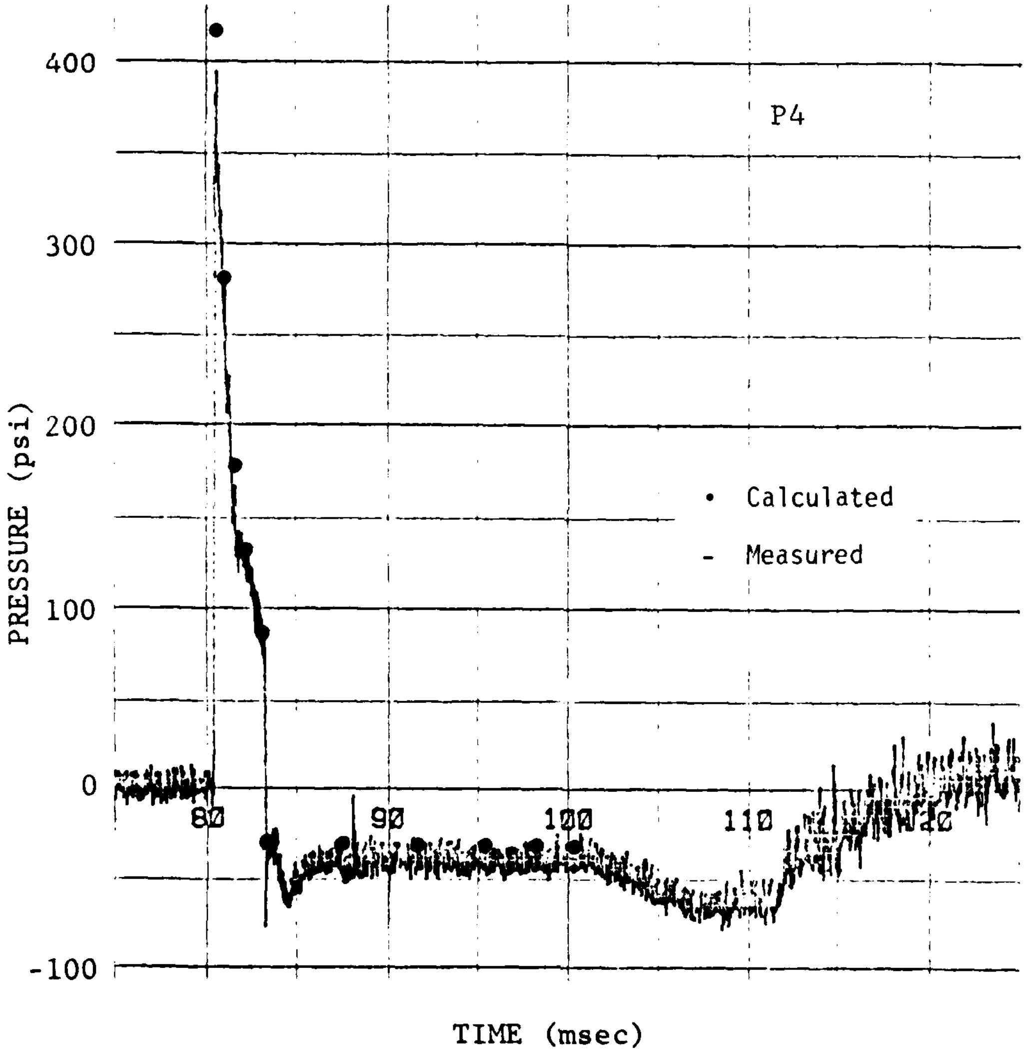

Figure 9. Calculated and Measured Pressure Histories at Point 3

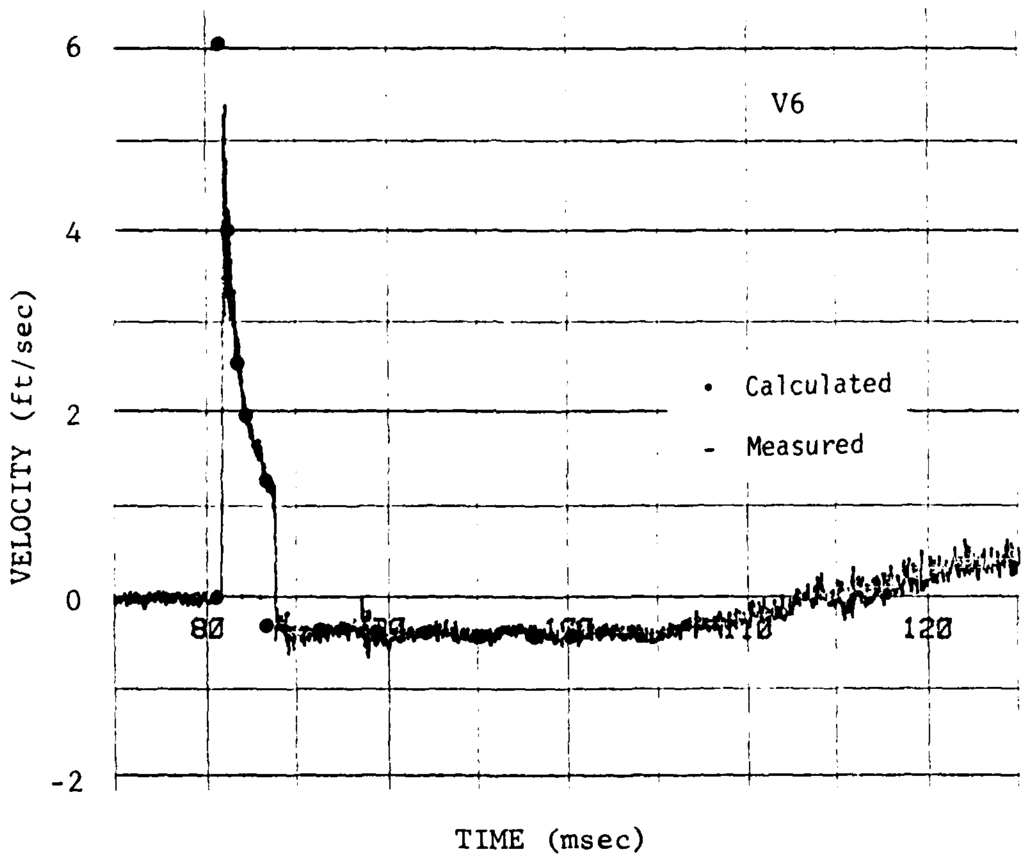

Figure 10. Calculated and Measured Horizontal Fluid-Particle-Velocity Histories at Point 3

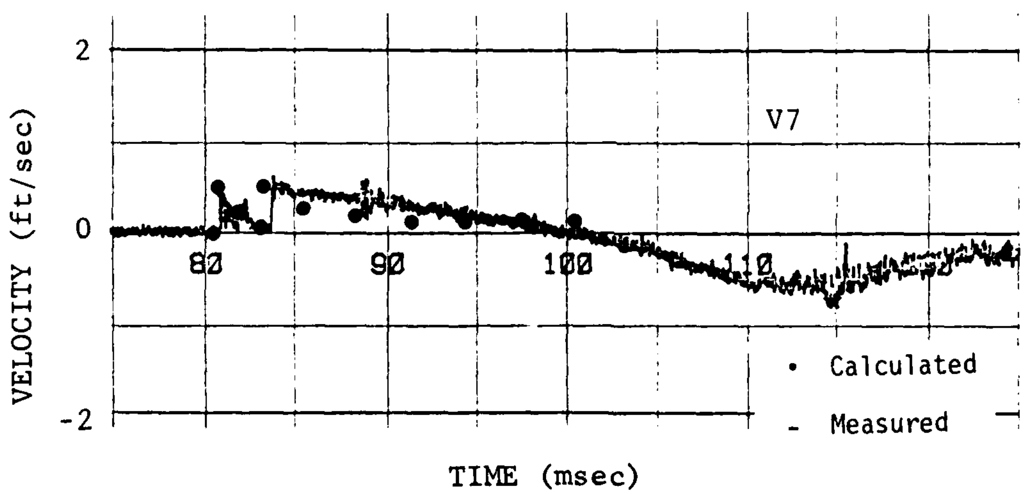

Figure 11. Calculated and Measured Vertical Fluid-Particle-Velocity Histories at Point 3

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1 J. A. DeRuntz, T. L. Geers, and C. A. Felippa, "The Underwater Shock Analysis (USA) Code, A Reference Manual", LMSC-D777843, Lockheed Palo Alto Research Laboratory, Palo Alto, California, 15 September 1980.

2 J. Gordon, private communication.

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